



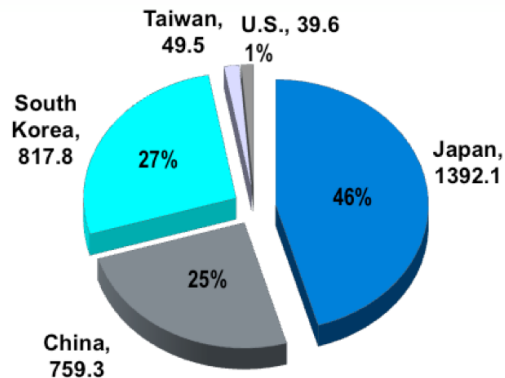
ARPA-E: Launching Energy Innovation in the 21st Century

May 24, 2011

<http://arpa-e.energy.gov/>

Wake Up Call

Lithium-ion battery manufacturing volumes in 2009
(millions of cells/year)



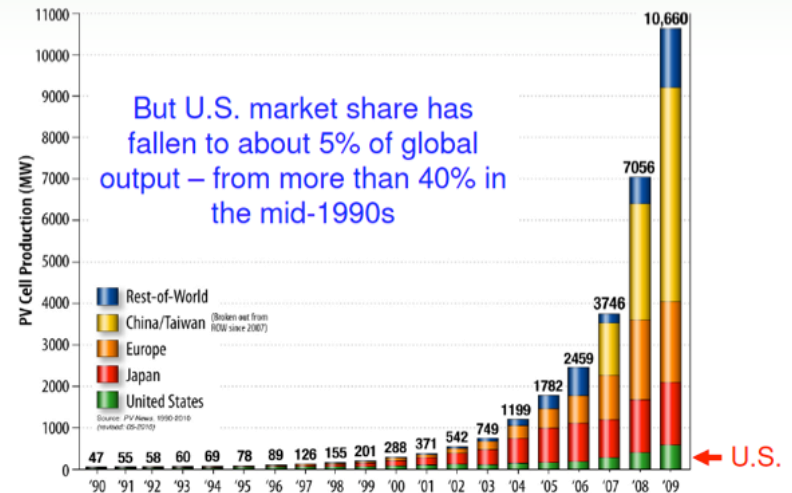
THE ENRICO FERMI AWARD

2009

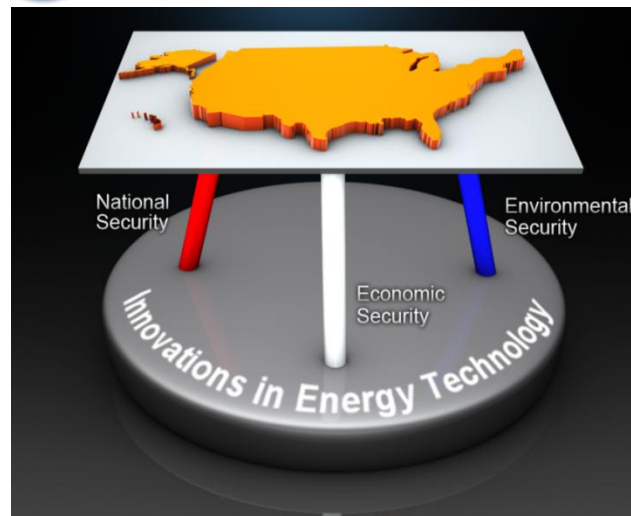
John Goodenough, U. Texas at Austin



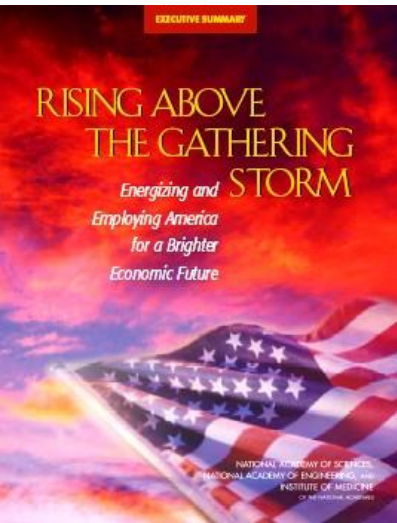
Solar PV is a booming global industry



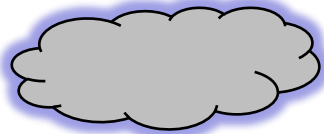
Worldwide production of solar photovoltaics – in Megawatts



Creation & Launching of ARPA-E



2006
Rising Above the Gathering Storm
(National Academies)



Innovation based on science and engineering will be primary driver of our future prosperity & security

2009
American Recovery and Reinvestment Act
(\$400M appropriated)

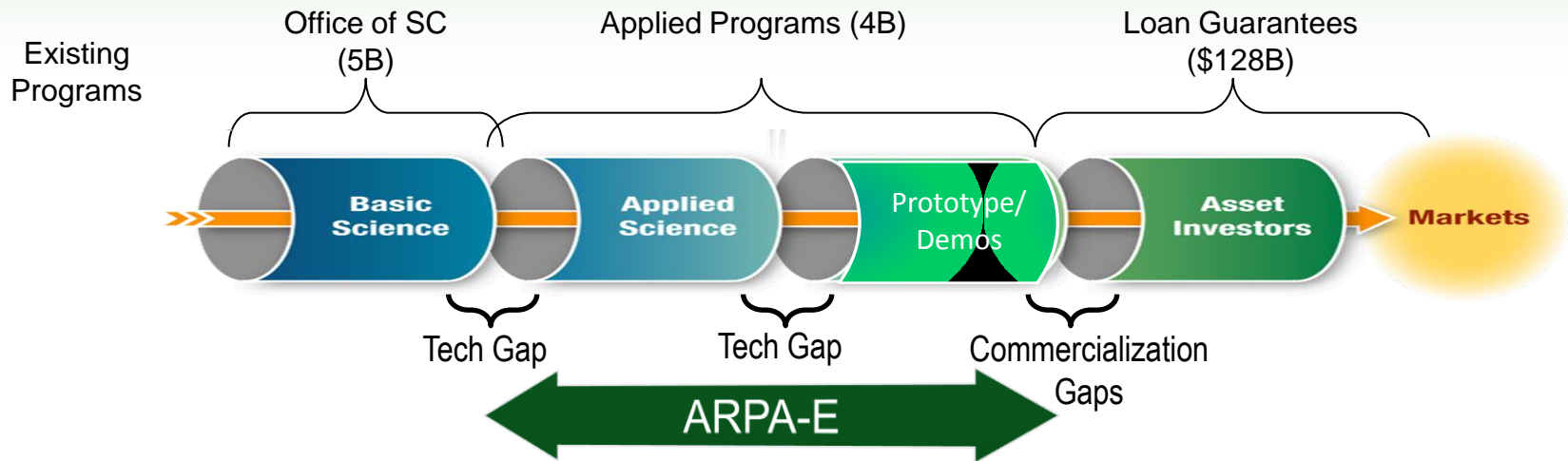
2007
America COMPETES Act

2011
FY2011 Budget
(\$180M appropriated)

President Obama launches ARPA-E at National Academies on April 27, 2009



ARPA-E was created with a vision to bridge gaps in the energy innovation pipeline



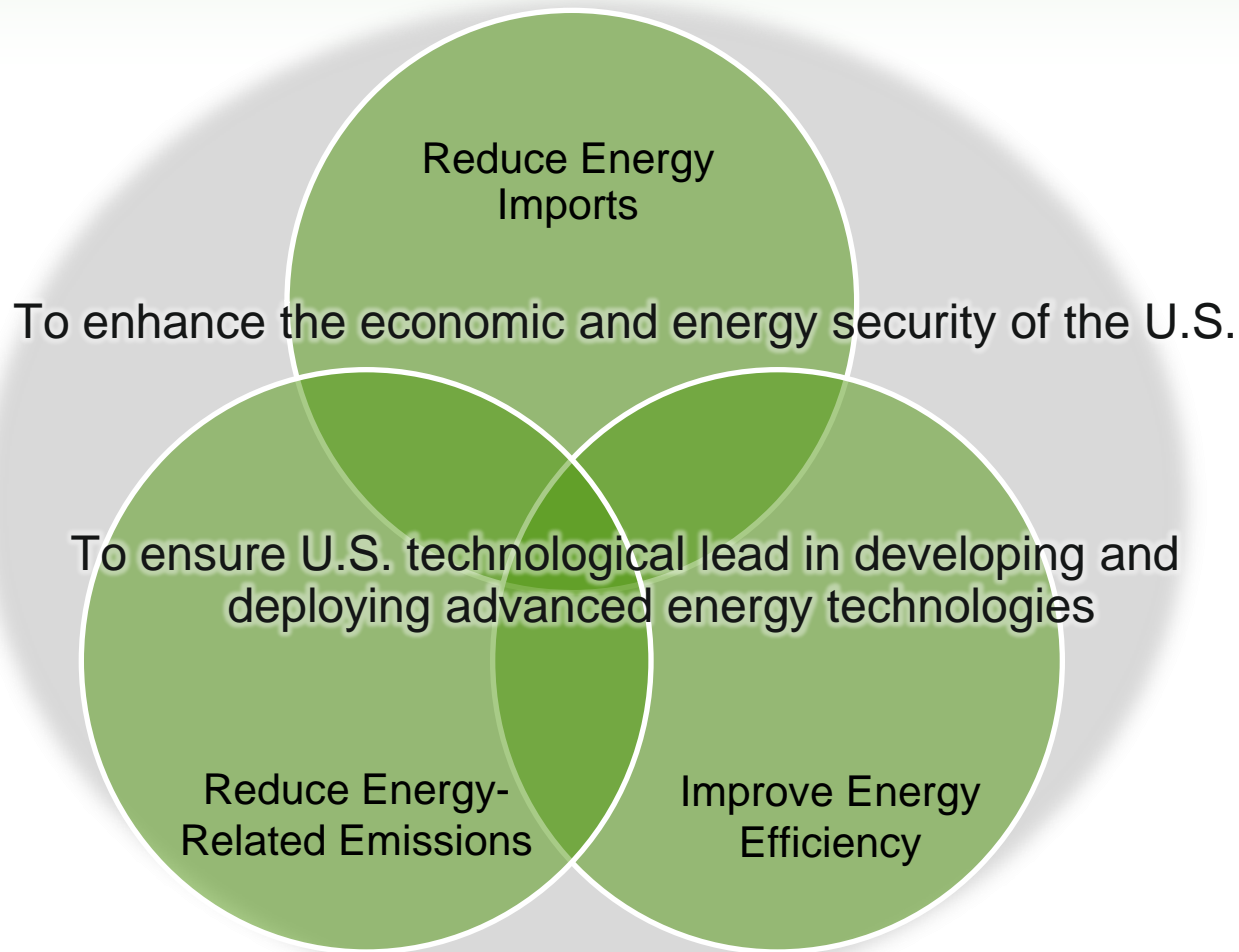
what ARPA-E will do

- Seek high impact science and engineering projects
- Invest in the best ideas and teams
- Will tolerate and manage high technical risk
- Accelerate translation from science to markets
- Proof of concept and prototyping

what ARPA-E will *NOT* do

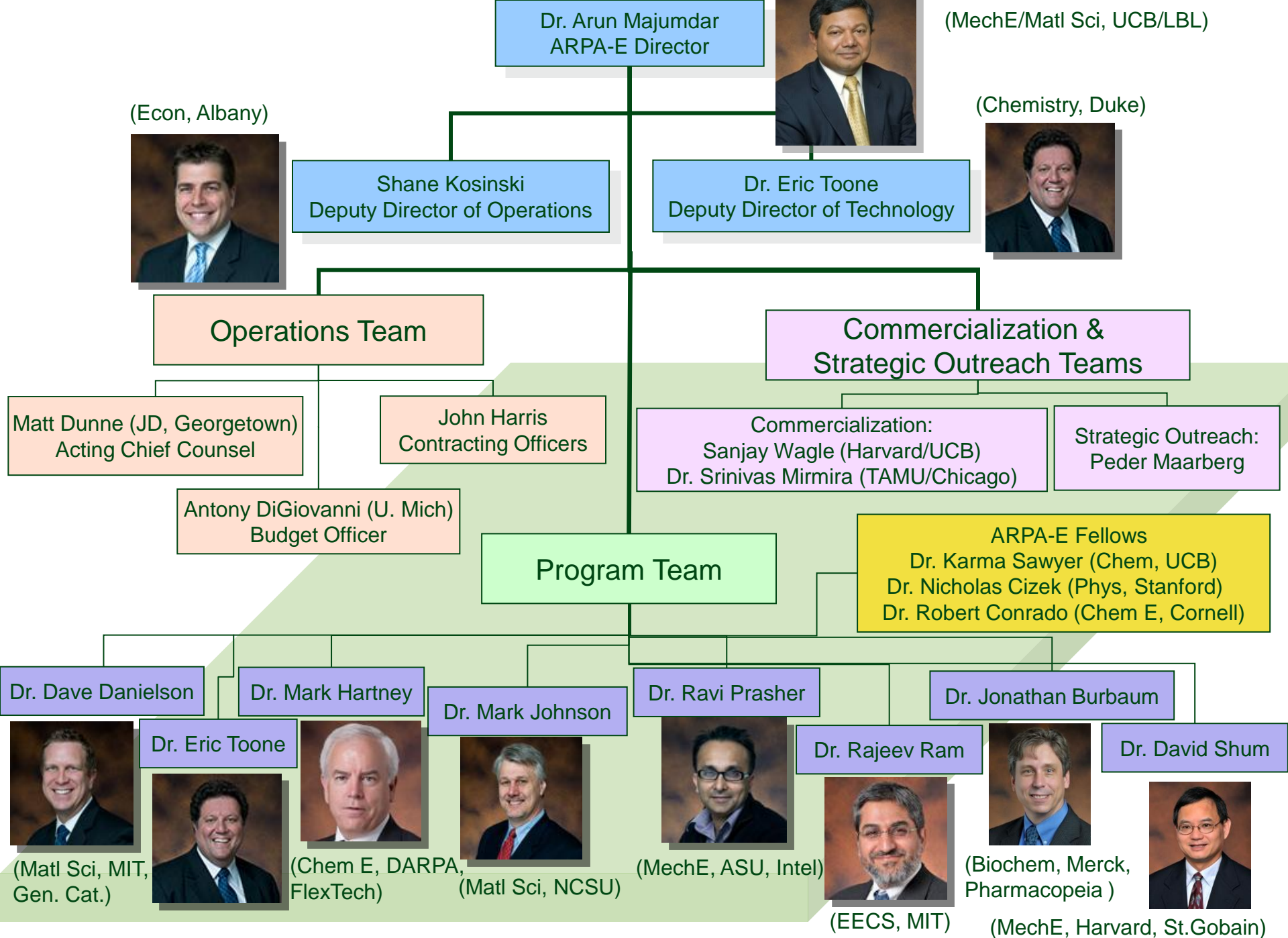
- Incremental improvements
- Basic research
- Long term projects or block grants
- Large-scale demonstration projects

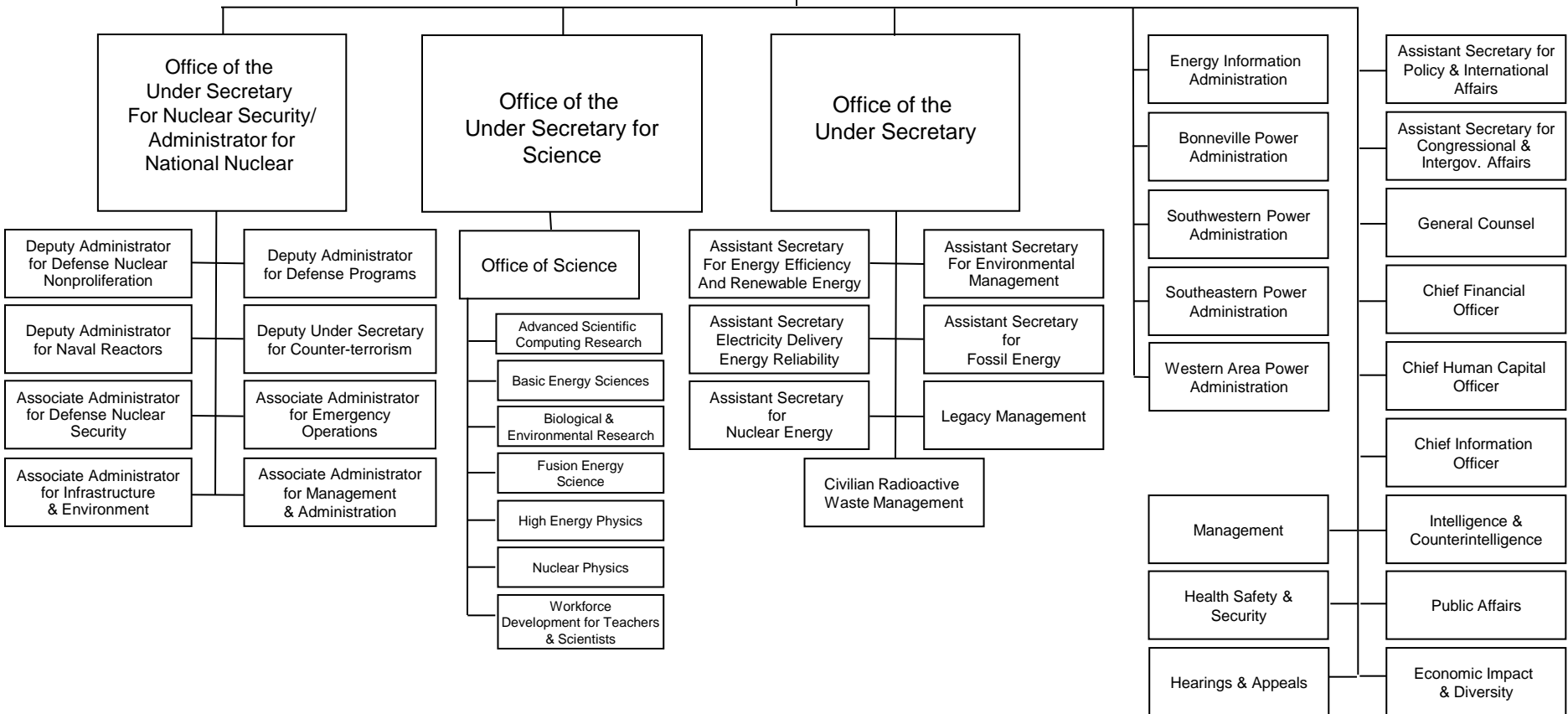
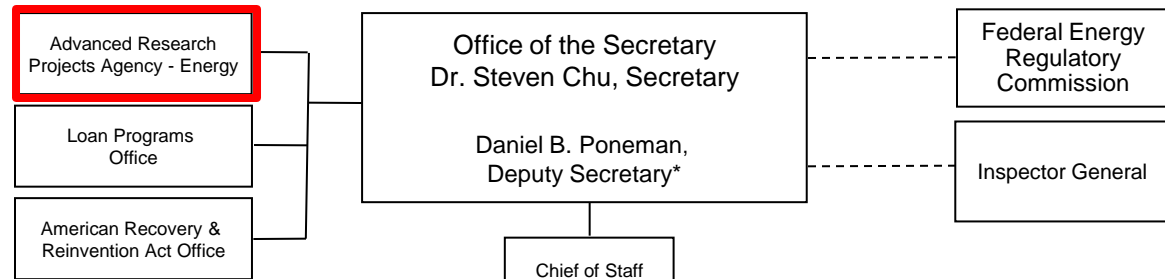
ARPA-E's Mission and Means



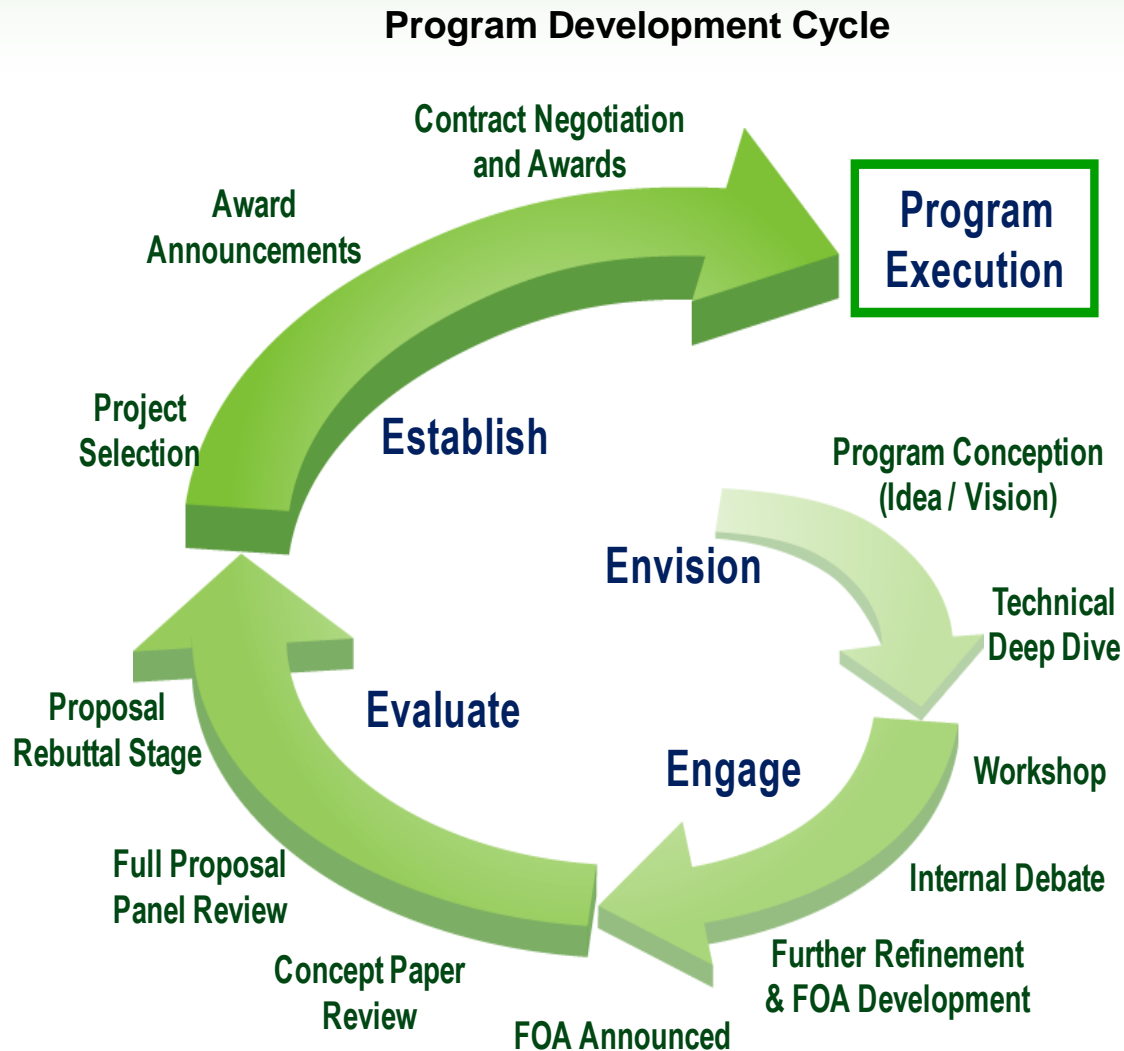
To overcome the long-term and high-risk technological barriers in the development of energy technologies.

- (A) identifying and promoting revolutionary advances in fundamental sciences;
AND
- (B) translating scientific discoveries and cutting-edge inventions into technological innovations;
AND
- (C) accelerating transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty.





ARPA-E's program development process is extremely fast



**From Program
Conception to
Execution in 6-8
Months**

An ARPA-E Project has four main attributes

IMPACT

If successful, project could have:

- High impact on ARPA-E mission areas
- Large commercial application

BREAKTHROUGH TECHNOLOGY

Technologies that:

- Do not exist in today's energy market
- Are not just incremental improvements; could make today's technologies obsolete

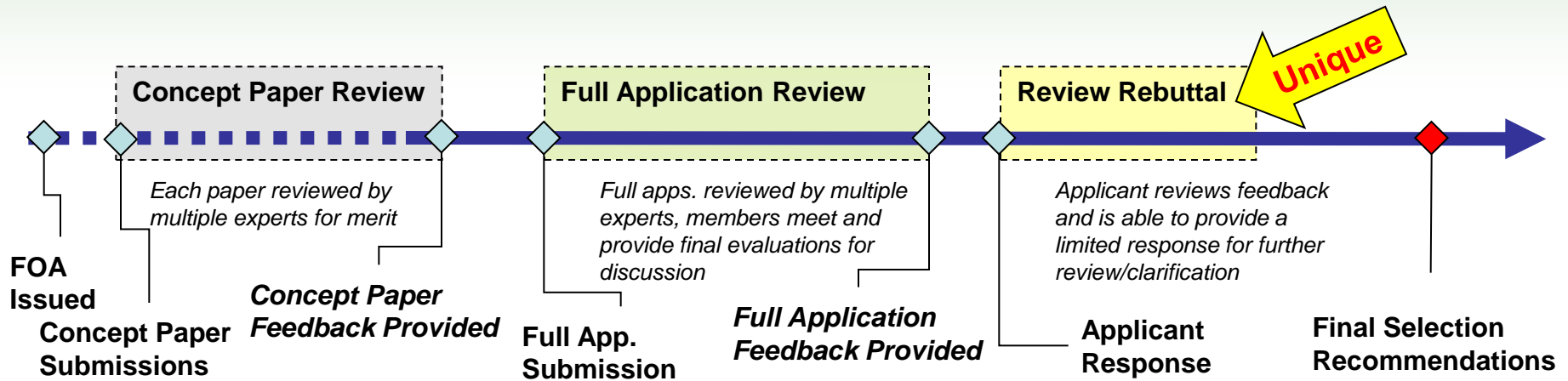
ADDITIONALITY

- Difficult to move forward without ARPA-E funding
- But able to attract cost share and follow-on funding
- Not already being researched or funded by others

PEOPLE

- Best-in-class people
- Teams with both scientists and engineers
- Brings new people, talent and skill sets to energy R&D

The Funding Opportunity Announcement (FOA) process is fast-paced, but deliberative

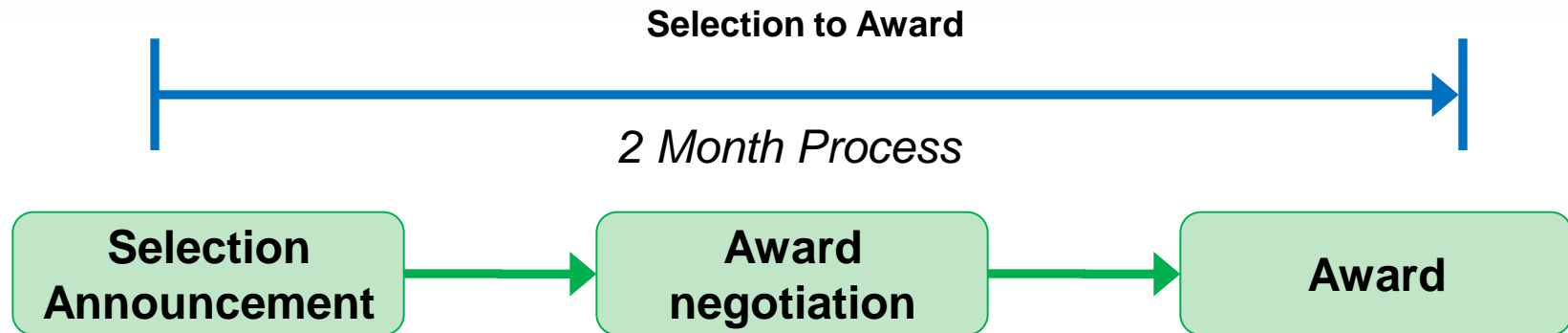


- ▶ 5-7 page summary
- ▶ Limits applicant expenses
- ▶ Reviewer comments provided to applicants

- ▶ Review by external, leading experts in the field
- ▶ External reviews critical to decision making – but scores do not get rack and stacked

- ▶ Applicants respond to reviews before selections
- ▶ Clarification improves final decisions

A streamlined contract negotiation and award process allows projects to begin promptly



- ▶ Aggressive internal and external deadlines established – move at the pace of business
- ▶ ARPA-E Technical, Contracting and Legal teams co-located – limits bureaucracy
- ▶ ARPA-E developed user-friendly negotiation guide and materials provided
- ▶ Jointly develop challenging technical milestones

“ARPA-E has consistently impressed and surprised us with the speed of their evaluation and contracting process, and the high caliber of their staff...We wish all R&D programs could adopt this degree of efficiency and professionalism” – ARPA-E Performer

ARPA-E's active program management promotes eventual project success

Program Management Tools

SCHEDULE



COST



TECHNICAL NOTES

Task 1: Chip Fabrication

	Subtask	Milestone	Technical Notes
	1.1: Deposit high capacitance materials	Q3: 20 microfarad capacitance achieved on 45 cm ² sample	Best capacitance to-date is 12 µF; new oxide material was proposed at last meeting to achieve target
	1.2: Improve etch performance	Q4: New etching tool installed	On-track: PO made last week, delivery set for Nov.

Active Program Management

- ARPA-E has a vested interest in the success of the project, we do not just provide a check
- Regular contact – at least two site visits per year, and formal quarterly reviews
- Help identify and resolve technical issues
- Annual community meetings

ARPA-E Currently has six focused programs plus a broad portfolio of projects from its first solicitation

Broad Solicitation



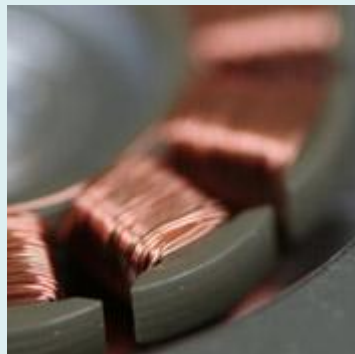
Transportation
Electrofuels BEEST



End-Use Efficiency
BEETIT



Stationary Power
ADEPT IMPACCT

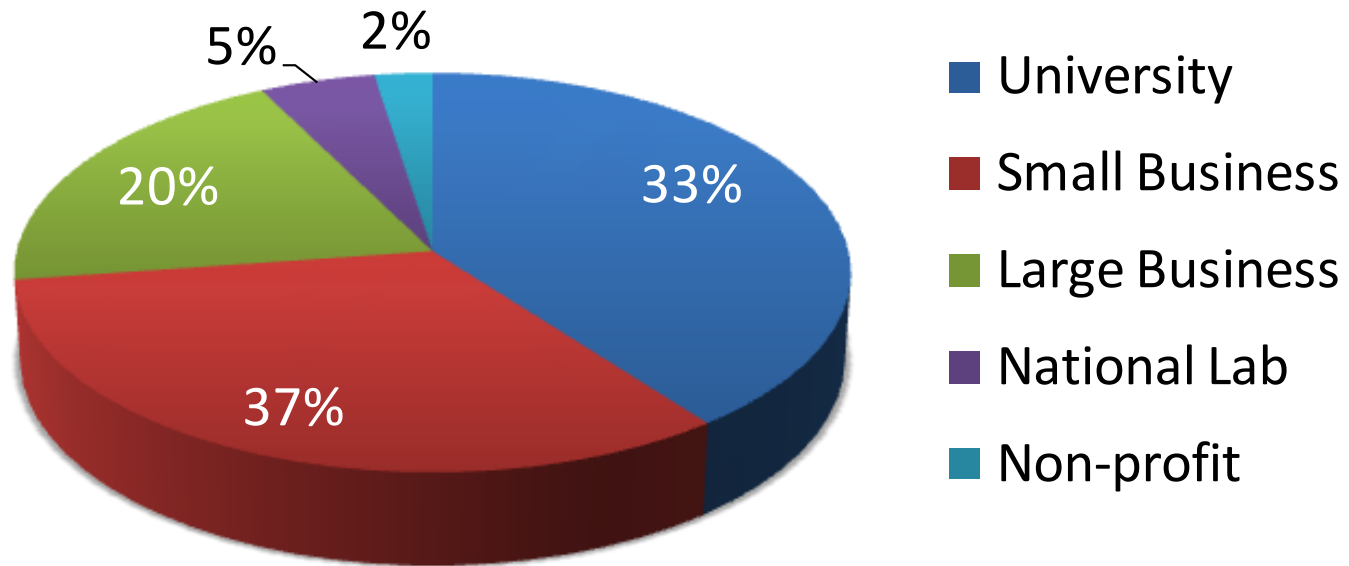


GRIDS



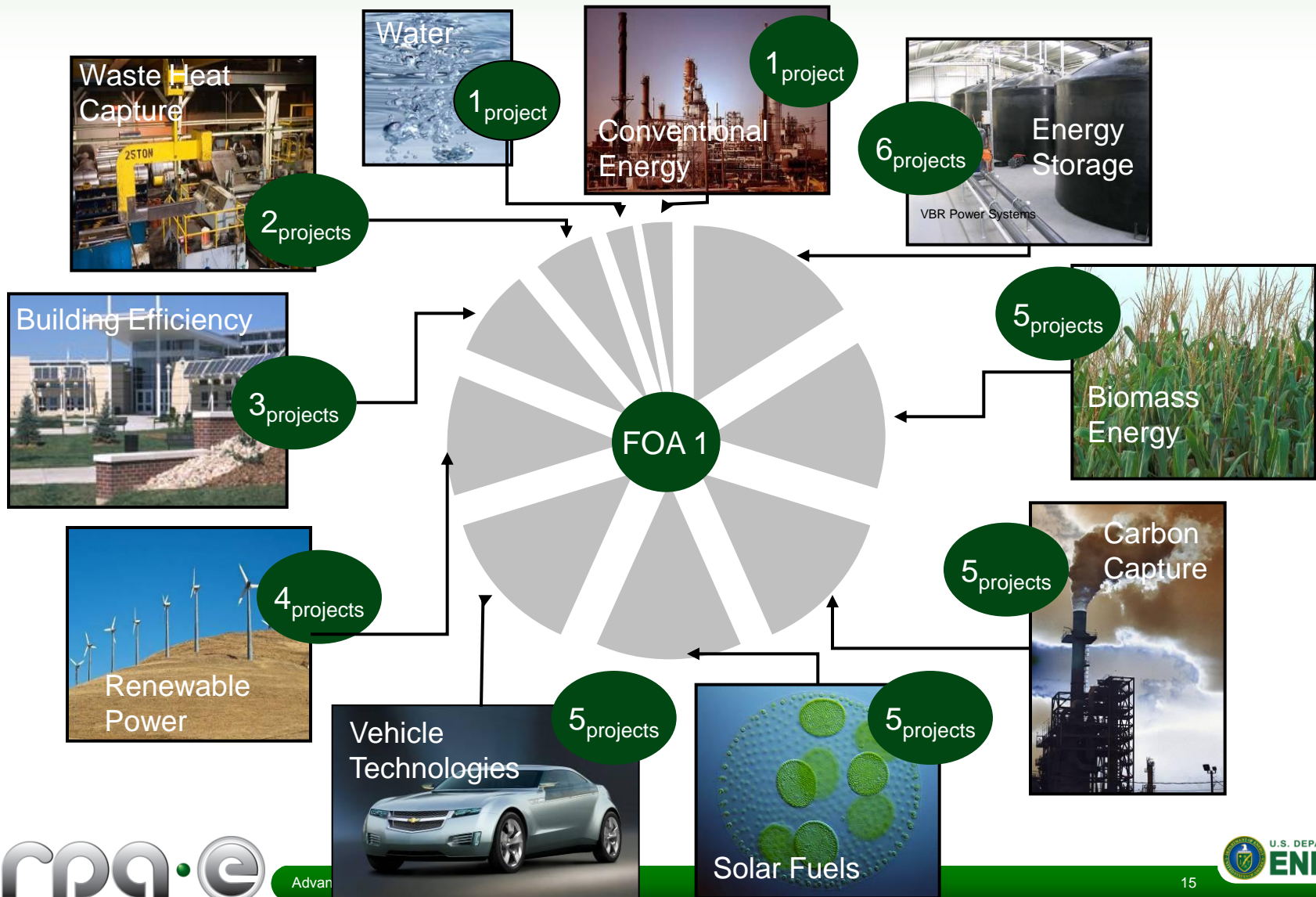
To date ARPA-E has made 121 awards from seven FOAs to a wide variety of organizations

**Project Breakdown by Lead Organization Type
(% based on award value)***

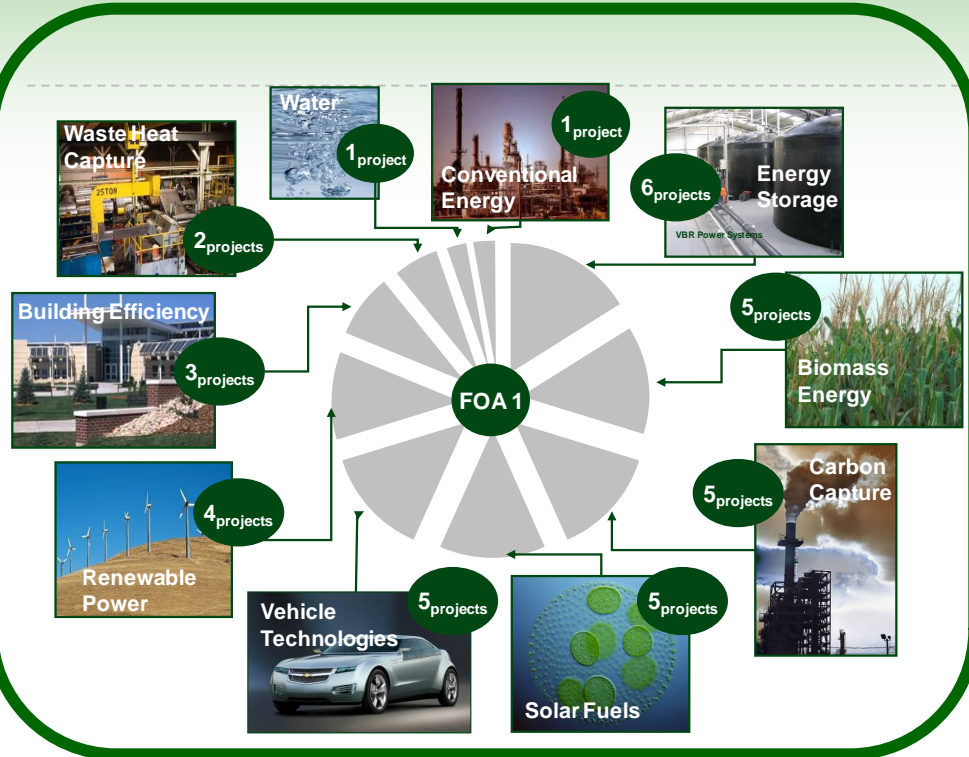


***Total Value of Awards = \$366 million**

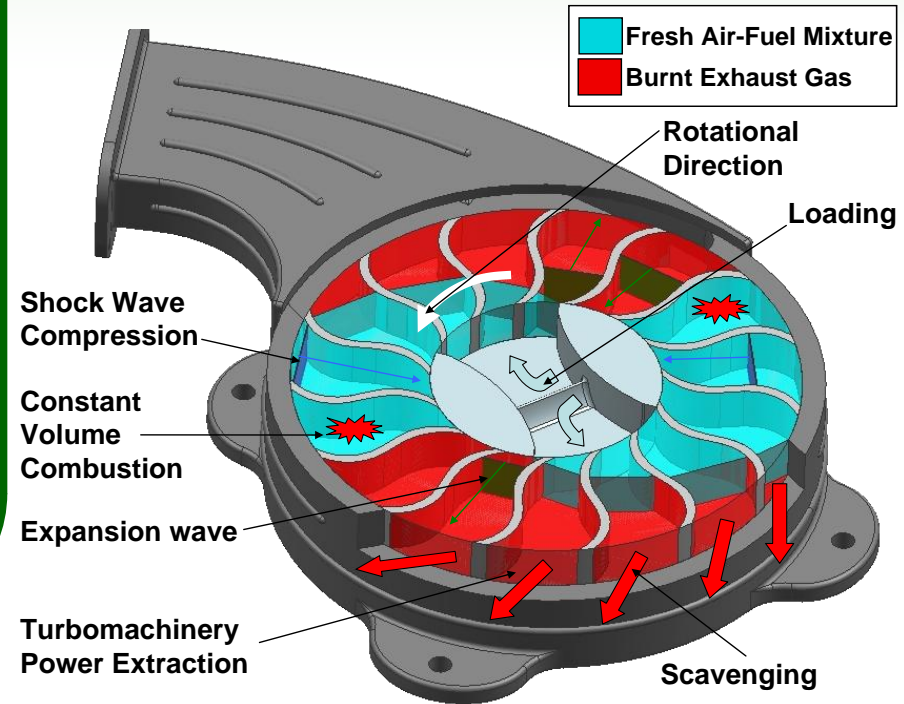
ARPA-E FOA 1 projects can be categorized into one of ten energy technology areas



FOA1



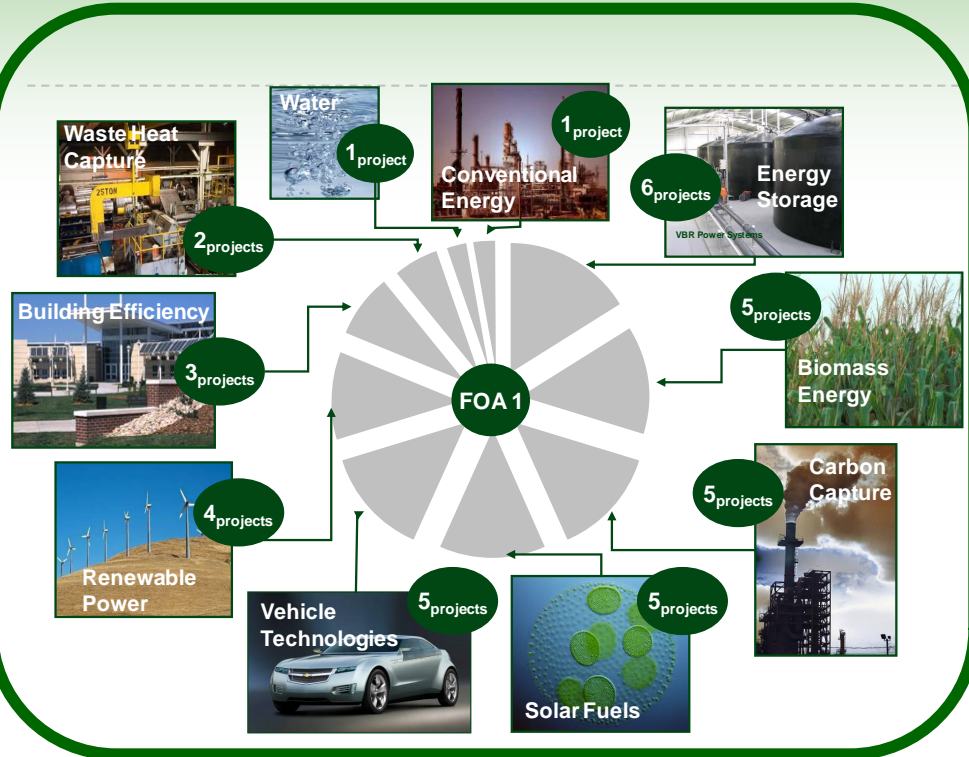
Wave Disk Engine



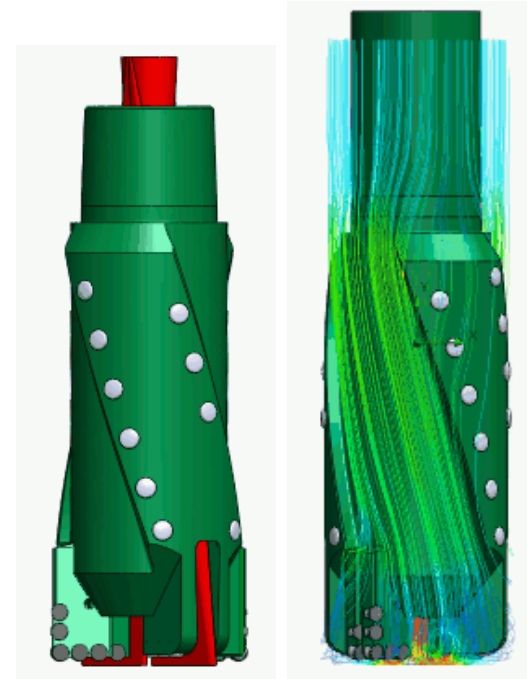
Dr. Eric Toone



FOA1



Low-contact drilling technology to enable economical geothermal wells



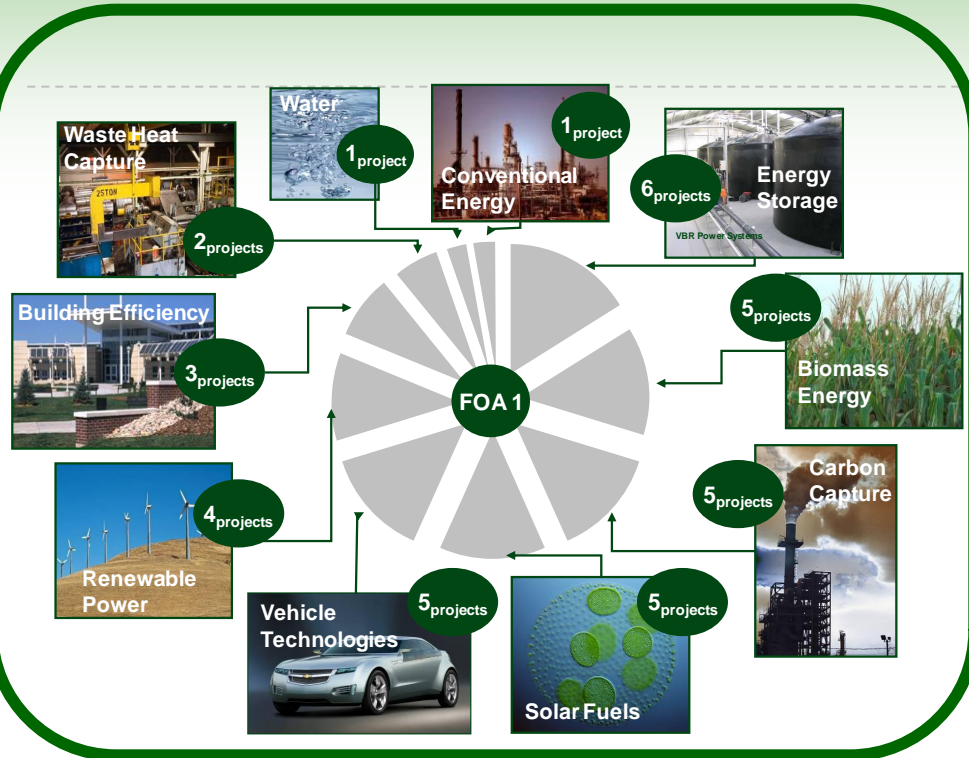
Dr. Dave Danielson



FORO
ENERGY



FOA1



Scalable production of macroalgae as a feedstock for biobutanol



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Broad Solicitation



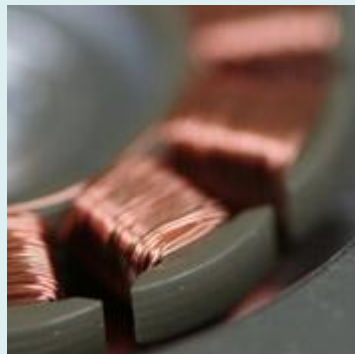
Transportation
Electrofuels BEEST



End-Use Efficiency
BEETIT



Stationary Power
ADEPT IMPACCT



GRIDS



Electrofuels

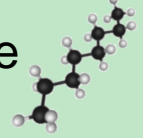
1. Assimilate Reducing Equivalents



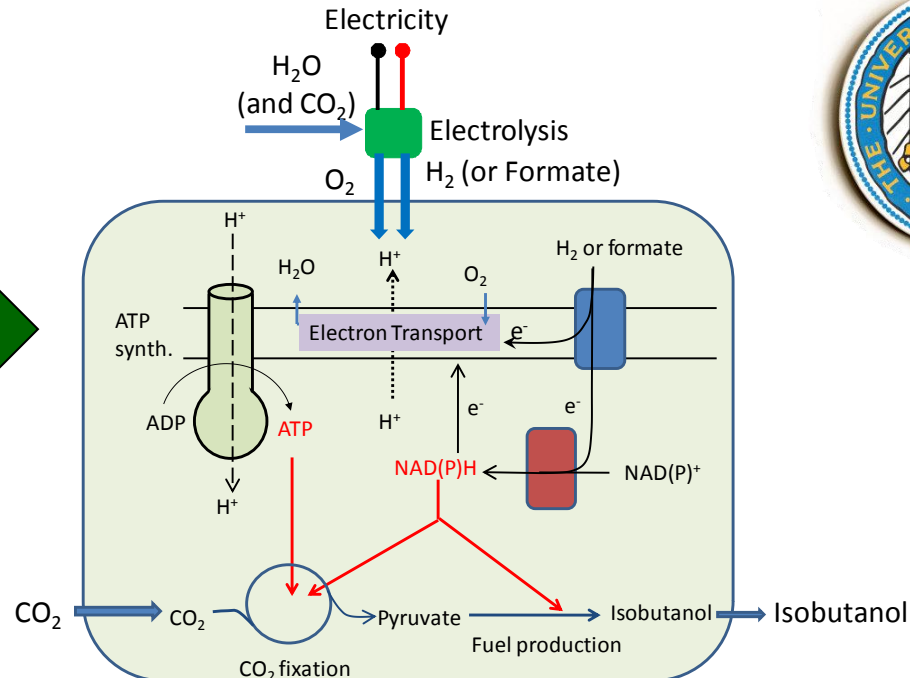
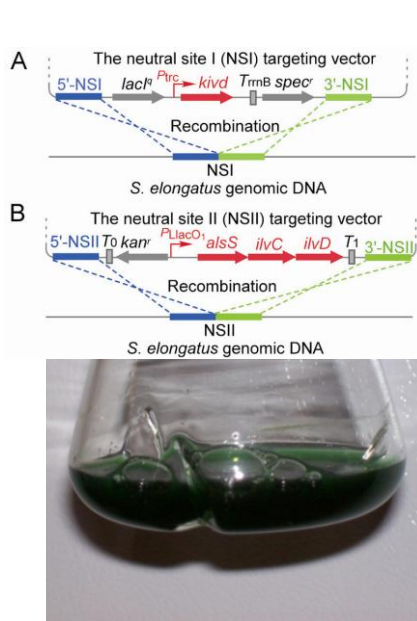
2. Fix CO_2 for Biosynthesis



3. Generate Energy Dense Liquid Fuel



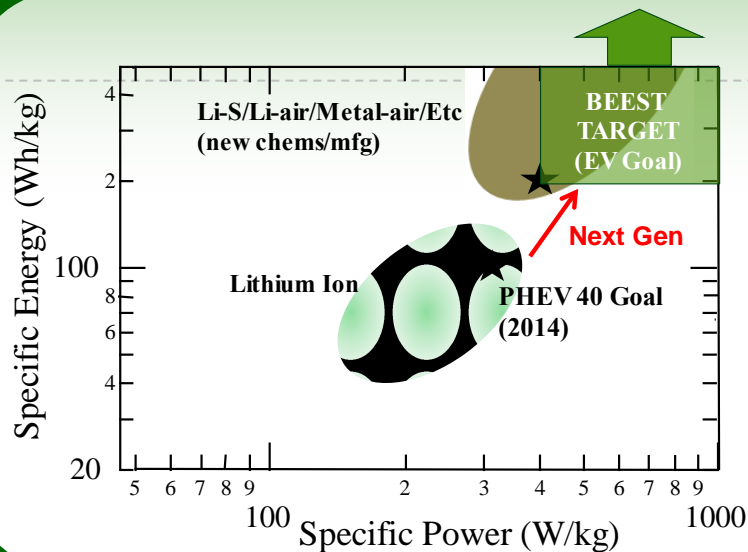
Electro-Autotrophic Synthesis of Higher Alcohols



Dr. Eric Toone



BEEST



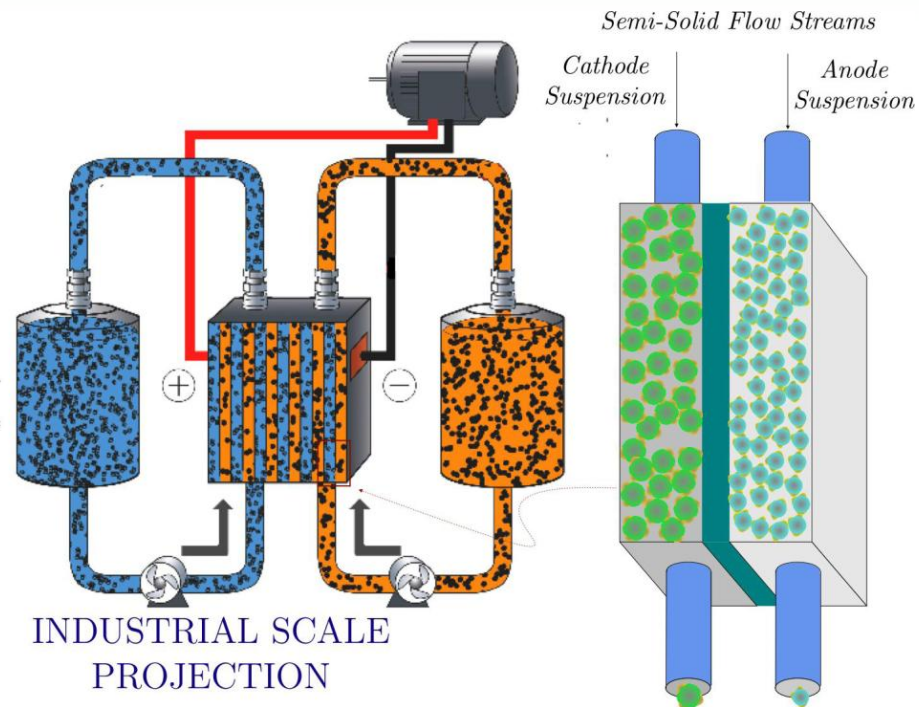
24M



Dr. Dave Danielson



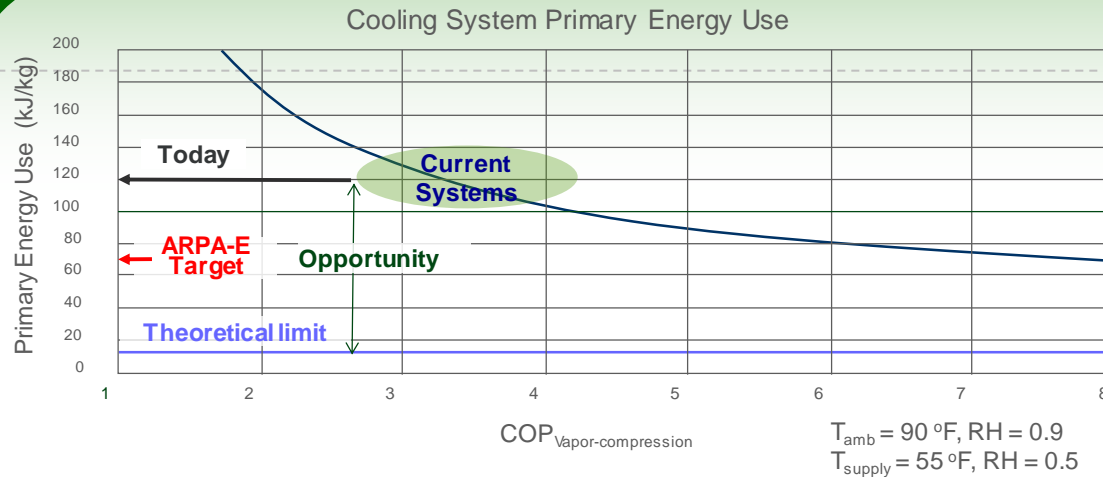
The Semi Solid Flow Cell (SSFC): Flow Batteries meet Solid Batteries



	Redox Density (M)	Voltage (V)
Aqueous Flow Battery	~ 2	~1
50% Solids SSFC	10-25	~3.5

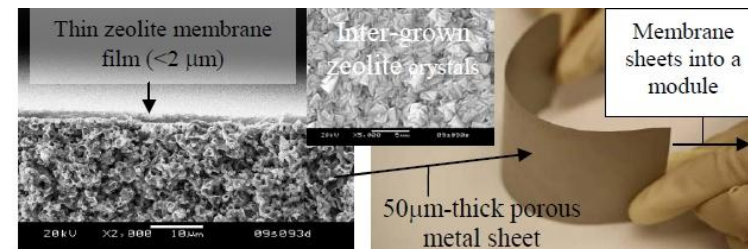
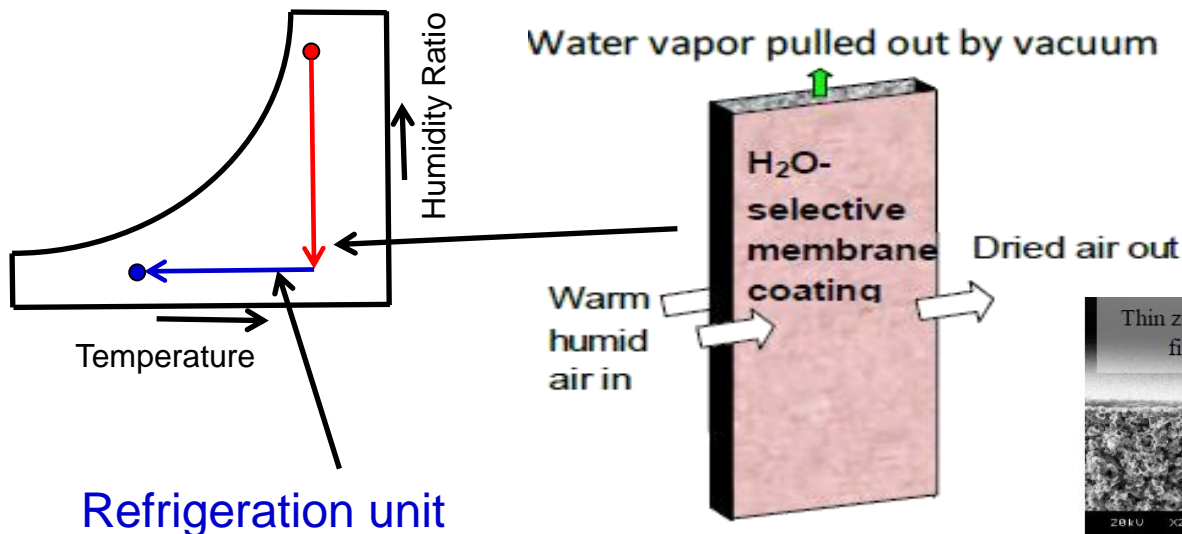
BEETIT

Dr. Ravi Prasher

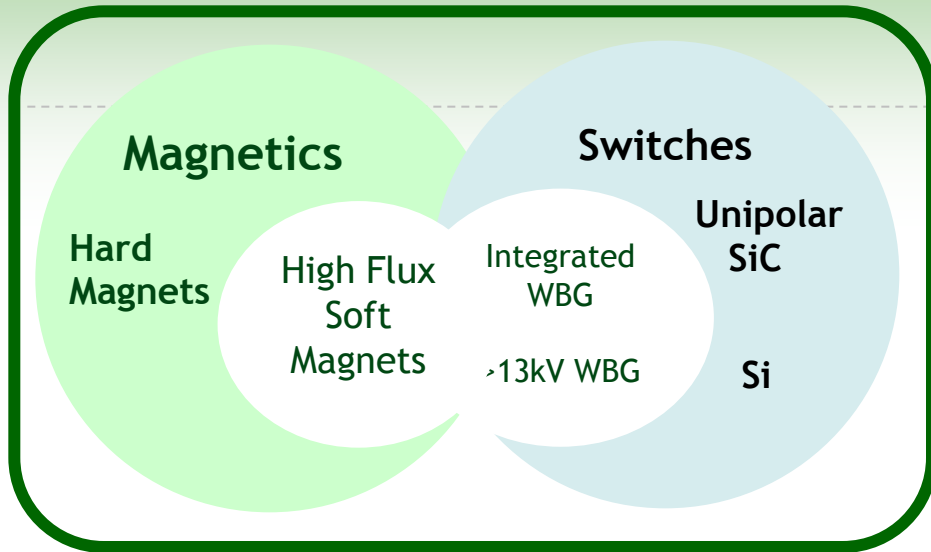


Reduce primary energy consumption by ~ 40 – 50%

High-Efficiency, on-Line Membrane Air Dehumidifier Enabling Sensible Cooling for Warm and Humid Climates

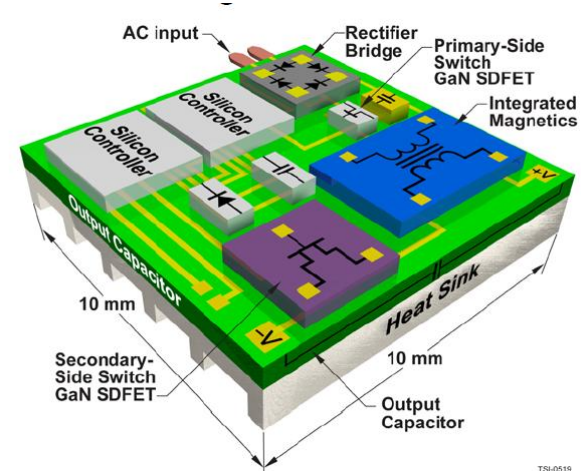


ADEPT



Chip-scale LED Driver for Commercial Lighting

25 Watt LED Electronics



300x reduction in power stage volume

Integrated Circuits for Power Systems

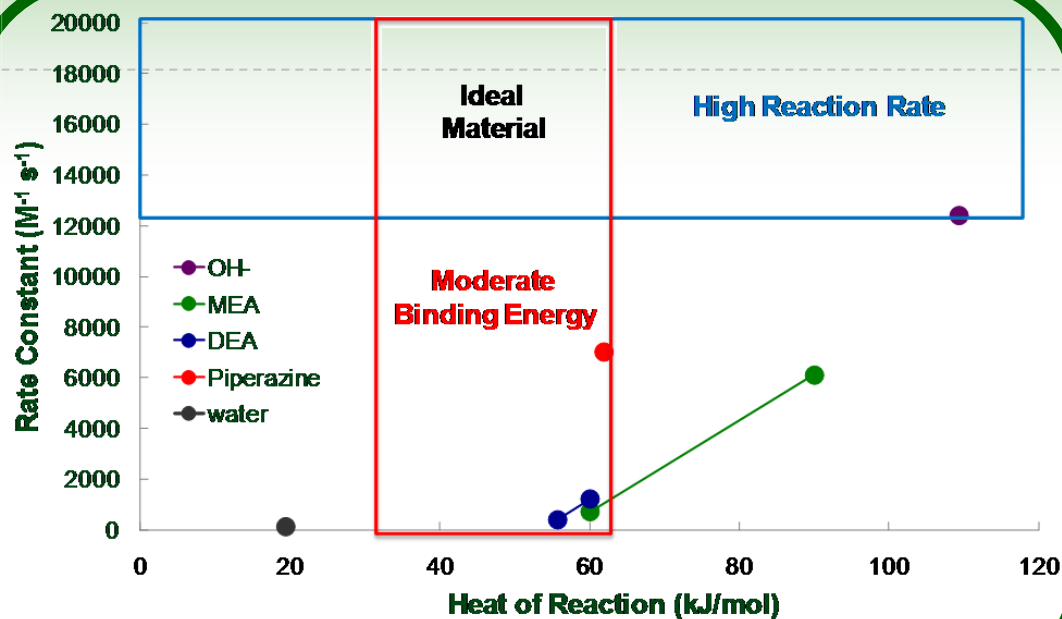
- On-chip inductors and transformers
- High-voltage transistors
- High-energy capacitors



Dr. Rajeev Ram

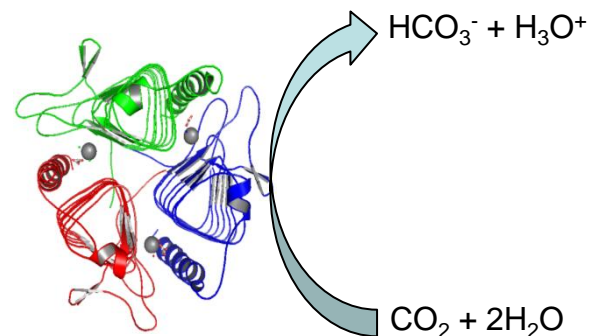


IMPACCT



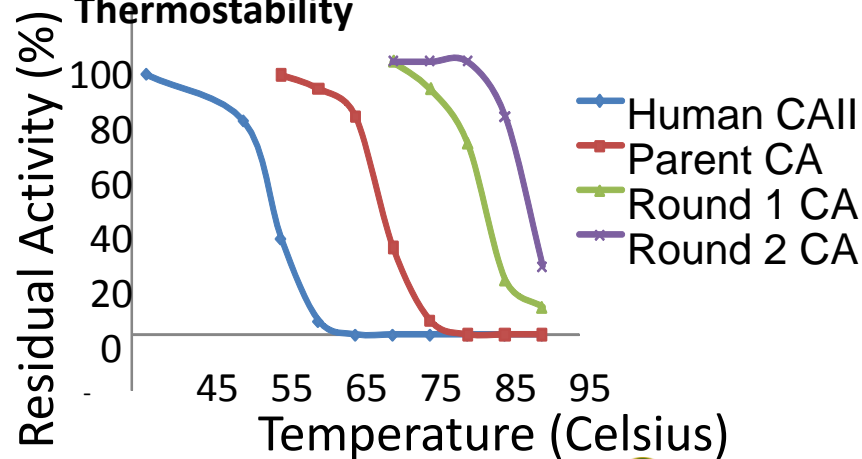
MEA = monoethanolamine, DEA = diethanolamine

Low-Cost Biological Catalyst to Enable Efficient CO₂ Capture

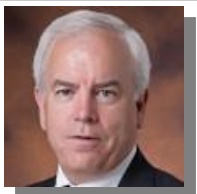


Carbonic Anhydrase (CA)

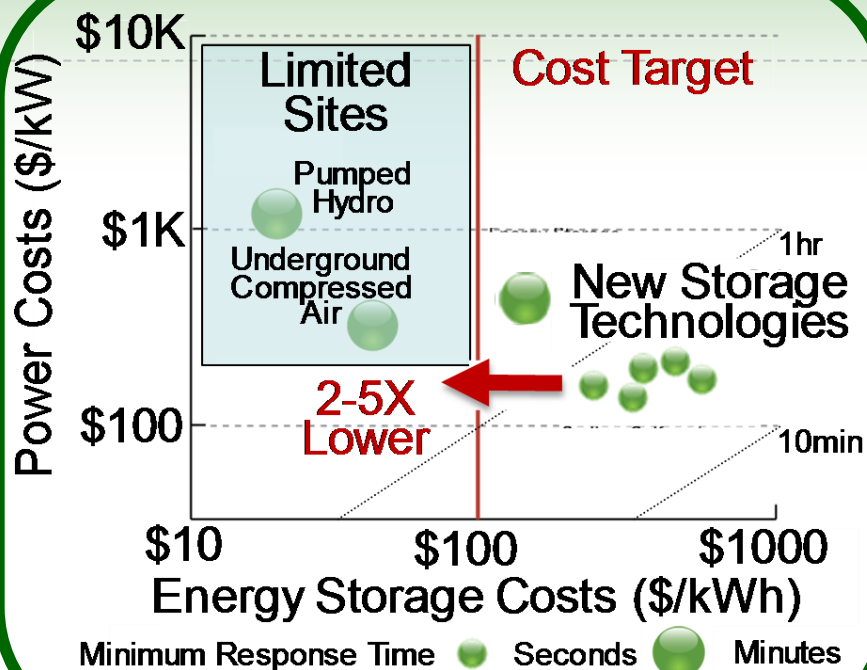
Thermostability



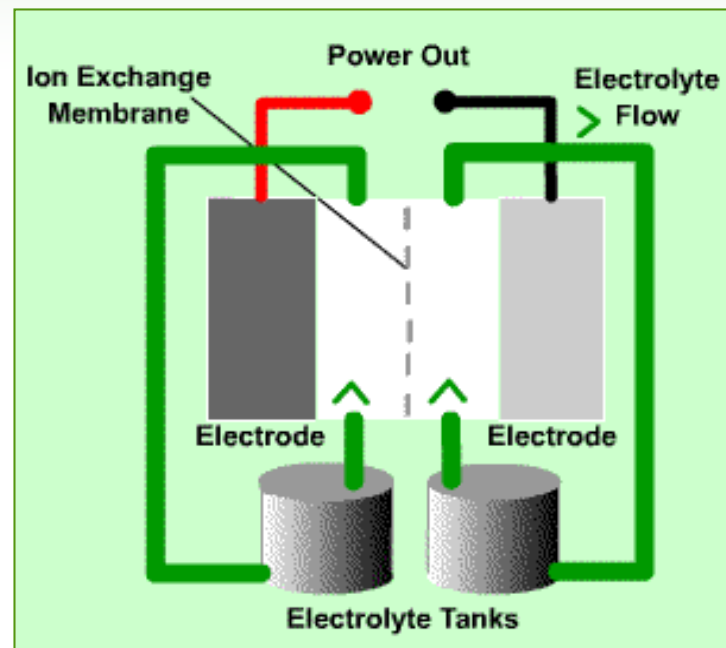
Dr. Mark Hartney



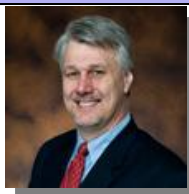
GRIDS



Transformative Electrochemical Flow Storage System



Dr. Mark Johnson

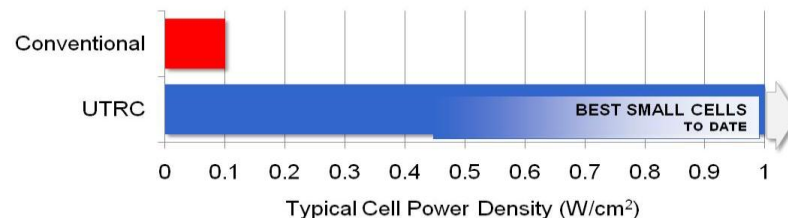


**United Technologies
Research Center**



Pratt & Whitney
A United Technologies Company

Pratt & Whitney Rocketdyne, Inc.



On April 21, 2011 Secretary Steven Chu announced up to \$130 million ARPA-E for five new program areas

"ARPA-E is unleashing American innovation to strengthen America's global competitiveness and win the clean energy race," said Secretary Chu. "In addition to creating new jobs, breakthroughs in clean energy technologies can reduce our country's dependence of foreign oil, decrease the cost of clean electricity, and build a sustainable infrastructure for future generations of Americans."

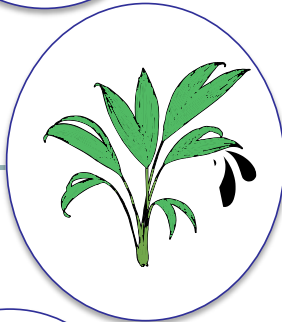
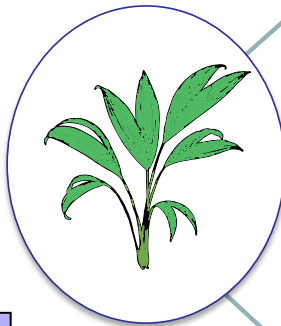
<https://arpa-e-foa.energy.gov>

Plants Engineered To Replace Oil (PETRO) ~ \$30M

PETRO aims to create plants that capture more energy from sunlight and convert that energy directly into fuels. ARPA-E seeks to fund technologies that optimize the biochemical processes of energy capture and conversion to develop robust, farm-ready crops that deliver more energy per acre with less processing prior to the pump.



- **Absorption:** Ordinary photosynthesis uses less than half of the incident light energy. Biological pigments that absorb more energy have been identified, but have not been used in biofuel production.



- **Metabolism:** Currently, biofuels are fermented from biologically created materials. The two biological processes are able to be combined into a single process to generate fuel directly.



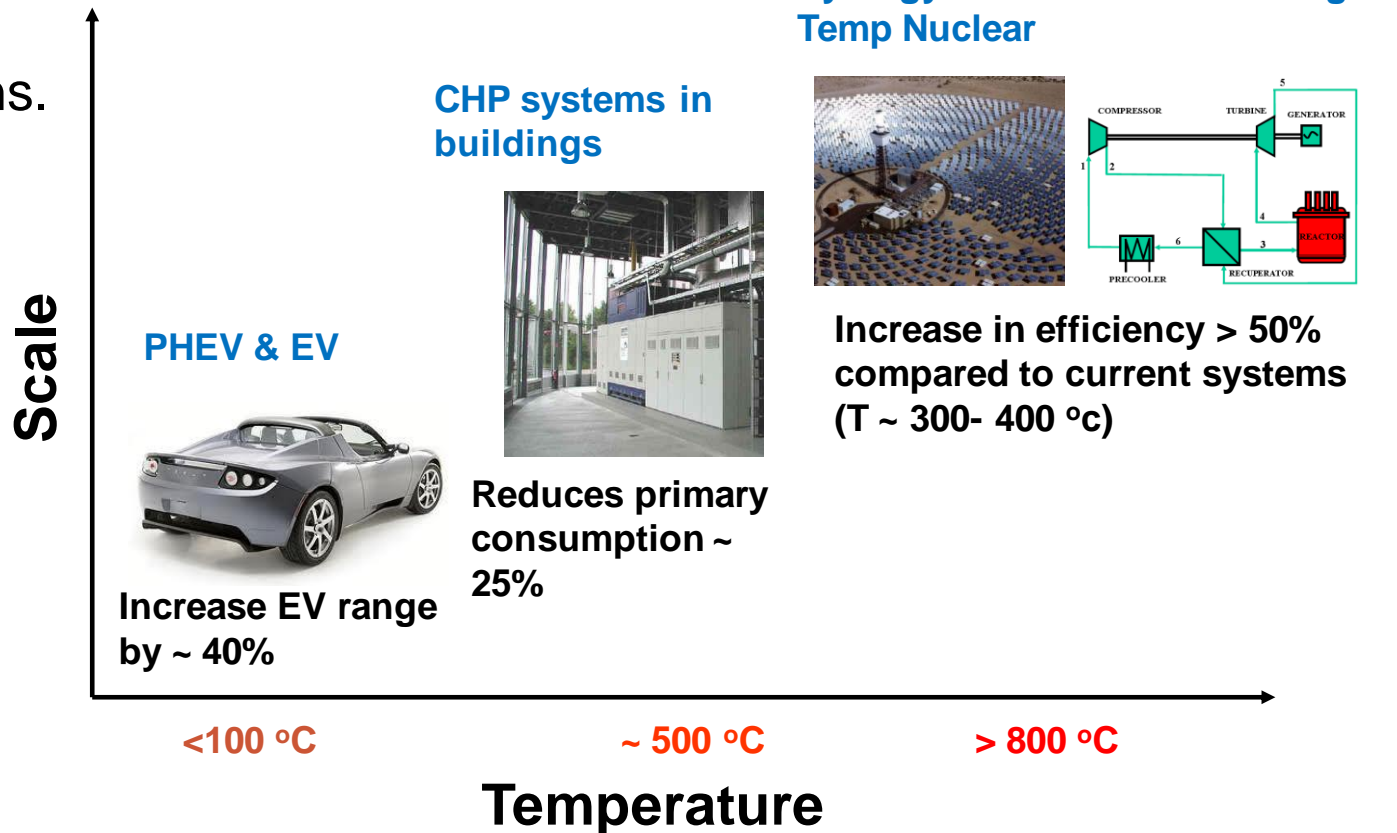
- **Optimization:** A dedicated source of biofuel is an agricultural crop. Rapid genetic selection can be used to accelerate the development of viable production strains.

Dr. Jonathan Burbaum



High Energy Advanced Thermal Storage (HEATS) ~ \$30M

More than 90% of energy technologies involve the transport and conversion of thermal energy. Therefore, advancements in thermal energy storage – both hot and cold – would dramatically improve performance for a variety of critical energy applications.



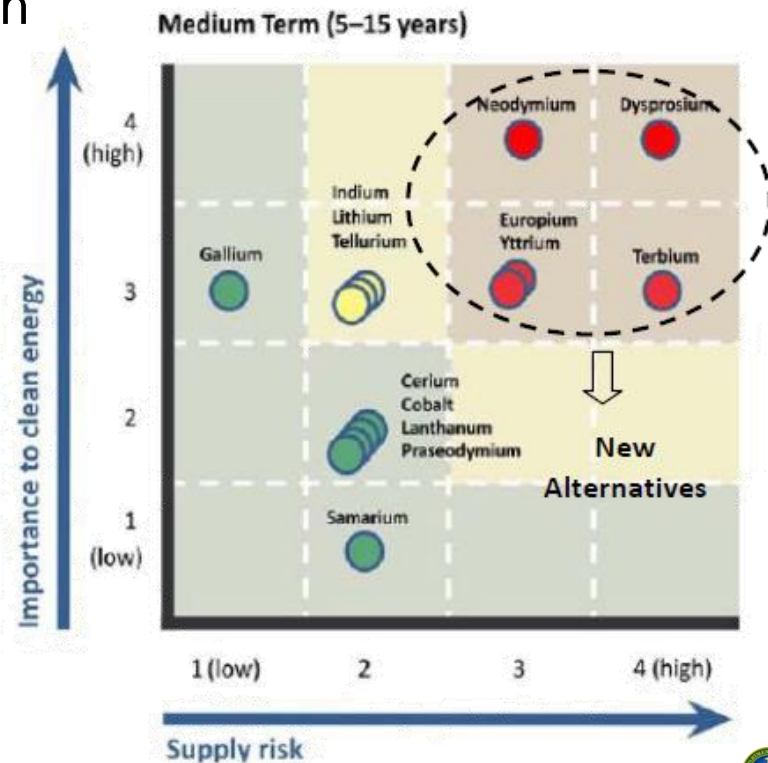
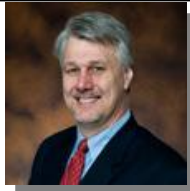
Dr. Ravi Prasher



Rare Earth Alternatives in Critical Technologies (REACT) ~\$30M

Rare earths are naturally-occurring minerals with unique magnetic properties. As demand for these technologies continues to increase, rare earths are rapidly becoming more expensive due to limited global supply – prices of many have increased 300–700% in the past year. ARPA-E seeks to fund early-stage technology alternatives that reduce or eliminate the dependence on rare earth materials by developing substitutes in two key areas: electric vehicle motors and wind generators.

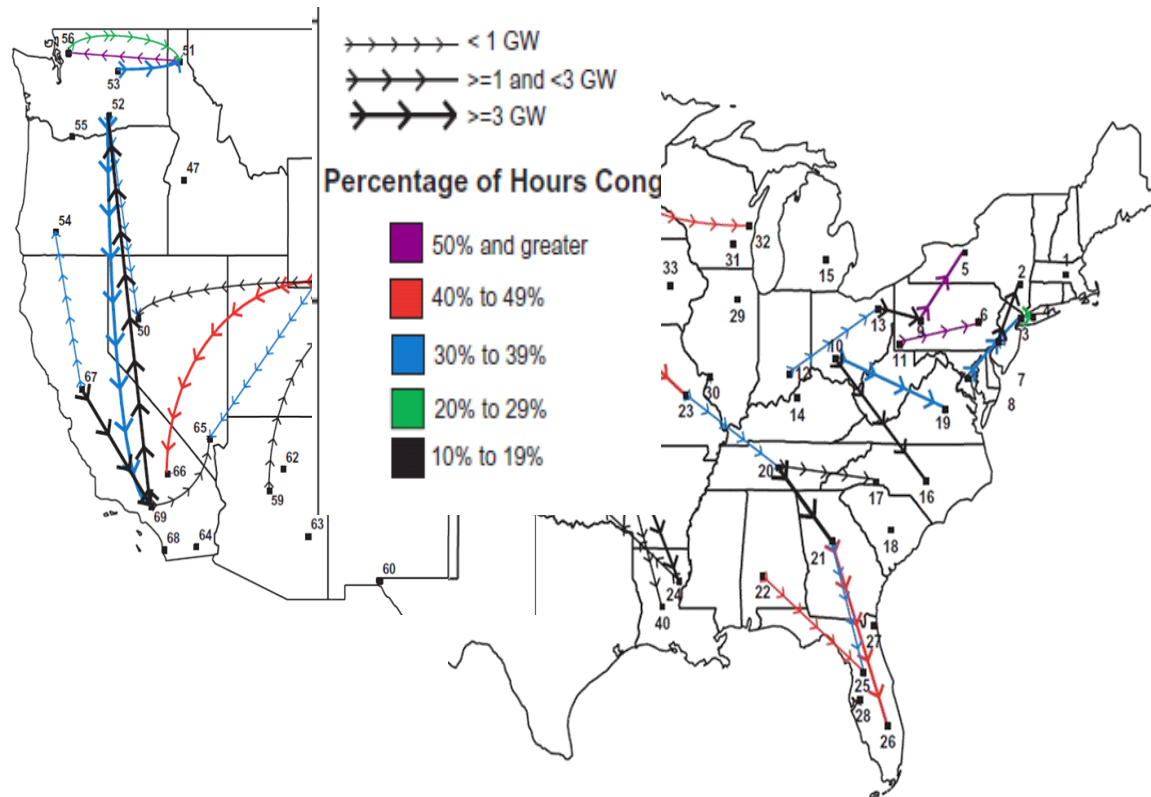
Dr. Mark Johnson



Green Energy Network Integration ~ \$30M

Advances in computation, networking, and grid monitoring allow delivery of electricity more efficiently and reliably than ever before. Today, however, one out of every five electricity dollars are lost to outages and 30 percent of the grid's hardware needs replacing. ARPA-E seeks to fund innovative control software and high-voltage hardware to reliably control the grid network.

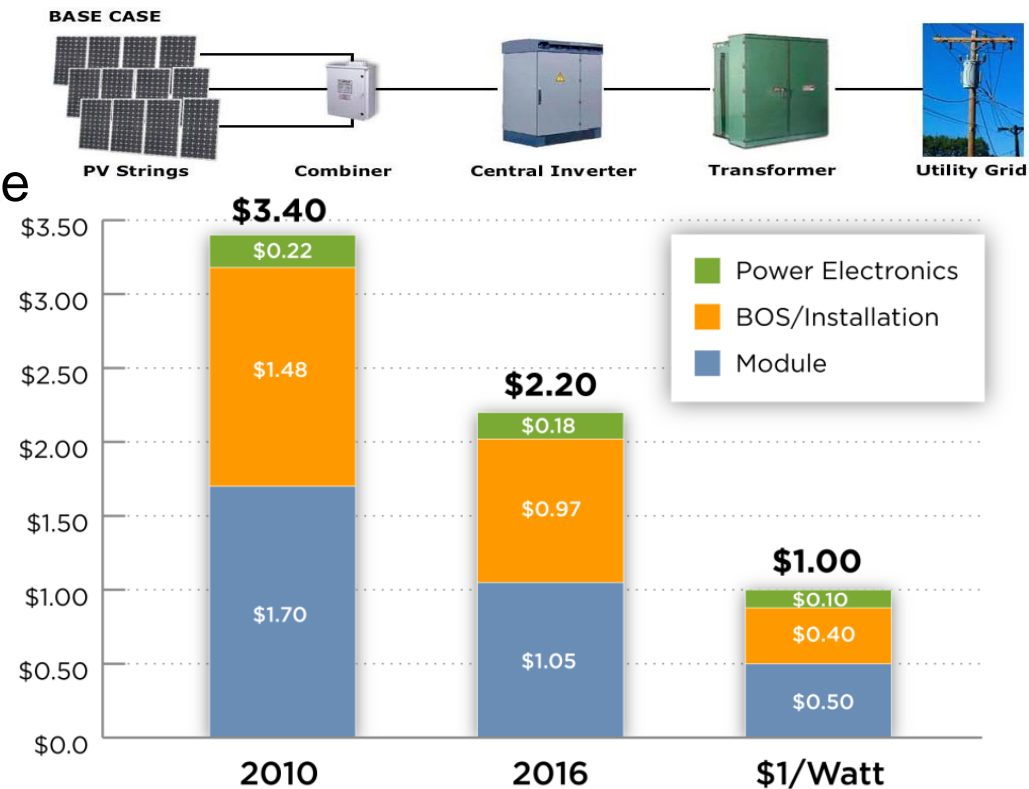
Dr. Rajeev Ram



Solar Agile Delivery of Electrical Power Technology (Solar ADEPT) ~ \$10M

SunShot leverages the unique strengths across DOE to reduce the total cost of utility-scale solar systems by 75 percent by 2017. If successful, this collaboration would deliver solar electricity at 6 cents/kWh - competitive with electricity from fossil fuels. This would enable solar electricity to scale and make the U.S. competitive in solar technology.

Dr. Rajeev Ram



5-6¢/kWh fully installed at the MW scale by 2020

ARPA-E has forged partnerships with key organizations

- DOD
 - ARPA-E formed a partnership with the DoD to jointly fund programs on integrating ARPA-E-funded next-gen power electronics and storage technologies to significantly increase the efficiency of power systems used in DoD applications
- Utilities
 - Duke Energy, Electric Power Research Institute (EPRI) and ARPA-E jointly announced a partnership which will provide the connective tissue for ARPA-E in the utility and stationary power sector.
 - Will provide a testbed for ARPA-E funded technologies (electric power management, vehicle charging, storage, power generation, carbon capture, electrofuels etc) in real systems, establishing their value and de-risking for commercial applications.
 - Will help ARPA-E identify opportunities to create technologies that will have value in the real world.

Thank you

<http://arpa-e.energy.gov/>

